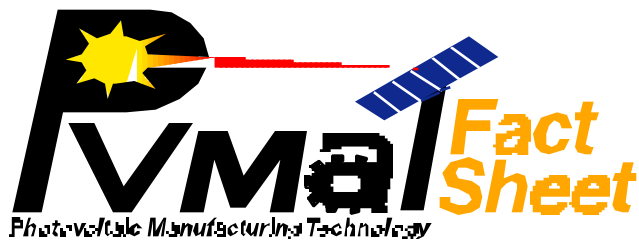


# A Modular Bi-Directional Power Inverter for PV Applications

## Highlights

- Completed an inverter design that is being incorporated into existing line of inverters
- New design is 30% smaller than comparable inverters, reduces parts cost by 35%, labor costs by 42%, and will sell for about 40% less
- New overcurrent protection system is being incorporated into existing product lines
- New UL-listed container system allows packaging of inverters, batteries, charge controllers, and disconnect devices

*This Trace Engineering project is part of the 1995 solicitation of PVMaT—a cost-shared partnership between the U.S. Department of Energy and the U.S. PV industry to improve the worldwide competitiveness of U.S. commercial PV manufacturing.*



## Trace Engineering

### Goal

The goal of Trace Engineering under the 1995 PVMaT solicitation was to develop a prototype for a modular, bi-directional DC-to-AC inverter for PV applications. Specific objectives of the inverter design were to:

- increase the manufacturing volume of the unit and allow the use of advanced production methods, which reduce manufacturing costs
- produce greater power density while cutting the number of components, which reduces material and inventory costs
- use a more compact design, which reduces chassis and enclosure costs.

### Background

PV is a modular technology in which panels can be combined to fit almost any type and size of application requiring electricity. Power inverters convert the DC electricity produced by PV systems to the AC electricity required by most applications.

Trace Engineering has been making inverters for PV applications for a long time. To meet the wide range of applications possible with PV systems, the company has designed and built numerous models of power inverters with a variety of power levels. For example, for just one of its lines of products—the SW series—Trace builds 32 different versions, most of which use customized transformers.

This great range of inverters, many of which are modified for specific applications, requires an extensive varied inventory, considerable worker training, and can complicate design—all of which increase costs. A standardized modular inverter circumvents these problems.

### Technical Approach

Under this PVMaT project, Trace developed a 2.5-kW modular inverter based on its SW series. The unit serves as a flexible building block for a variety of needs. It can be connected in parallel to increase power, in series to increase AC voltage, or in a series and

parallel combination to increase both power and voltage. It may be interconnected for single, split, or three-phase configurations for both 60 Hz (domestic) and 50 Hz (international) applications. The design also allows constructing units with different DC input voltages and AC output voltages to further satisfy various application and market requirements.



*Trace streamlined its product manufacturing and improved reliability through a modular, versatile building-block inverter design.*

Standardizing on a single "building block" module avoids the need to build multiple modules and sizes for different applications. Plus, a building-block inverter eliminates the need to oversize a system in anticipation of future expansion; instead, the inverter configuration can be very closely matched to load and can be easily expanded when the need demands. All of this results in higher manufacturing volume of a single design, which improves manufacturing and results in greater reliability by reducing low-volume modifications. This lowers the cost and improves the performance of PV systems.

A standardized modular inverter also improves the operating efficiency of PV systems. This is because with a modular system, inverters can be turned on or off as required by the AC load. This keeps the system operating near peak efficiency for each module. And it enables the system to operate at greater than 90% efficiency over a wider range than do single, large inverters.

Finally, a modular inverter system improves reliability of operation by allowing "N+1" redundancy. That is, by using one more inverter than is required to handle a given load, a defective module can be shut off when a problem occurs, without disrupting the inverter system or loads.

## Results

Trace Engineering has designed, built, and demonstrated a prototype power inverter. The prototype is 30% smaller than comparable power inverters, and it reduces parts costs by 35% and labor costs by 42%. The prototype was designed using the existing chassis of the company's SW series, which illustrates the manufacturability of the inverter. Trace expects that the improvements made with this design will cut the retail price by about 40%.

The prototype inverter incorporates a newly developed overcurrent protection circuit. All Trace inverters use overcurrent protection circuits to protect inverters from loads that exceed the inverter's output capacity. The new circuit developed under this PVMaT project, however, was such an advance over other systems that Trace decided to adapt it to its existing DR and SW series product lines. The result has been substantially improved factory yields and significantly reduced field failures.

The prototype inverter is not only less expensive than its counterparts, but also incorporates several advances, including a new overcurrent protection circuit and new control systems.

Trace also developed new control systems for the prototype inverter, one of which enables the use of multiple inverters in either single-phase or three-phase applications. This system employs both hardware and software to coordinate the operation of the inverters and to split the loads being powered.

Another software, control system simplifies and improves communication among inverters. This system not only enhances operational efficiency, but also improves inverter reliability, provides fault tolerance, and improves the ease of trouble shooting systems in the field.

To accommodate the modular inverter and all the balance-of-system components, Trace developed a modular packaging system—the Power Module system. This is a compact cabinet that comes equipped with the required AC and DC protection breakers and disconnects. Individual cabinets can be connected together and stacked up to four high. The stacks themselves can be interconnected for system expansion. Each stack can accommodate inverters, batteries, charge controllers, and disconnect devices for a PV system. The Power Module system was tested by Underwriters Laboratories and has been listed under UL category 1741 (Standard for Power Conditioning Units for Use in Residential PV Power Systems). This listing indicates that the Power Module system is a safe and reliable product for use by consumers.



*The Trace Power Module system is a compact, modular package that can be stacked to accommodate an inverter and its balance-of-system components.*

Thanks to the success of this PVMaT project, Trace Engineering is currently producing the Power Module system and has plans to produce a 2.5-kW modular inverter for commercial markets.

## Company Profile

Trace Engineering is located in Arlington, Washington. The company has been manufacturing power inverters for more than 13 years and has built more than 300,000 inverters. Although the company makes inverters for marine use, recreational vehicles, back-up power, and more, most of its inverters have been used in renewable energy applications.

Until recently, Trace concentrated on the stand-alone, non-utility-interactive applications. With the introduction of the Trace SW series in 1994, Trace expanded its product line into utility-interactive and larger hybrid system applications.

Trace Engineering is the world's largest manufacturer of inverters for photovoltaic applications. Currently, the company has 250 employees and is still growing.

## References

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FS-520-24460

DOE/GO-102000-1090

July 2000



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